Applied Mathematical Sciences, Vol. 8, 2014, no. 25, 1223 - 1230
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http://dx.doi.org/10.12988/ams.2014.4164

Generalization Index of the Economic Interaction Effectiveness between the Natural Monopoly and Regions in Case of Multiple Simultaneous Projects

Irina Nizovtseva

Ural Federal University
Office 602, Turgeneva str. 4,
Ekaterinburg, Russia, 620075

Abstract

In this paper we continue to develop indicator that determines the quality of the interaction regions with natural monopolies. Is considered a generalized example of interaction in which the work is carried out simultaneously on several projects. In an apparent form obtained formalization index interaction to connect the two projects. Indicated by the upper and lower bounds of efficiency for mixed projects

Keywords: Natural monopoly, interaction index, effectiveness ratio

1. Introduction

Let's proceed directly to development and economic and mathematical formalization of the interaction index between the natural monopoly and a region for a general case of parallel implementation the projects which belong to an approved (fixed) complex regional development program. For the special case model was built and tested in the works [1, 2].

The parallel implemented projects Π^m (the vertical tubes of the sandwich-model) constituting a complex regional development program are named as natural numbers m=1,2,3.

The proposed overall effectiveness ratio k^m and the methodology of its practical calculation for each project Π^m separately are taken as a basis. A formula to calculate the effectiveness of interaction on the Π^m project coefficient in the new designations is the following (look [1,2]):

$$k^m = \frac{D^m_{\text{forecast}}}{D^m_{\text{forecast}} + \frac{1}{T}\sum_{i=1}^{T}\left(\sum_{j=1}^{s}(D^j_{\text{dep}})^m_i\right) + \frac{1}{T}\sum_{i=1}^{T}\left(\sum_{j=s+1}^{n-q+l}\left|(R^j_{\text{loss}})^m_i\right|\right)}.$$

Here T is the program duration (range of planning) expressed trough the number of reporting units (time periods) of the covering perspective (for instance, 10 years).

There is a value D^m_{forecast} in the numerator. D^m_{forecast} is predicted average income of the natural monopoly per unit of time from the project Π^m implementation (implemented separately from other projects). Income from investments, inflationary processes, the natural monopoly profit from the project Π^m results (increase of traffic volumes and loading and unloading volumes and etc.) are considered in this value. A formula and a method of D^m_{forecast} determination are given in [3, 4].

A value $(R^j_{\text{loss}})^m_i$ is losses of a company in the i time period (year) in the result of interaction with an economic unit P_j in the frames of Π^m project. Here the node P_j is invested by raised or borrowed funds. From a mathematical point of view $(R^j_{\text{loss}})^m_i$ is a negative value. Thus, the modulus of this value $\left|(R^j_{\text{loss}})^m_i\right|$ placed in the denominator of the expression for k^m can be interpreted as the funds volume that could be saved by refusing from interaction with a node P_j in the indicated form.

There are two non-negative summands in the denominator of the expression, except the predicted averaged income per the unit of time D^m_{forecast} from the Π^m project, for calculation the effectiveness ratio k^m from the Π^m project: $\frac{1}{T}\sum_{i=1}^{T}\left(\sum_{j=1}^{s}(D^j_{\text{dep}})^m_i\right)$ is an averaged possible alternative income of the P_0 company per the unit of time that could be obtained in the case of total rejection from the investment activity in the Π^m project in the region and alternative placement the entire volume of investments on bank deposits; $\frac{1}{T}\sum_{i=1}^{T}\left(\sum_{j=s+1}^{n-q+l}\left|(R^j_{\text{loss}})^m_i\right|\right)$ is the averaged possible volume of the company's P_0 saved funds per unit of time which would be saved by company in the case of total rejection from the receivables investment activity in the frames of the Π^m project with nodes-enterprises of the region.

2. Introduction interaction index of interdependent projects

The main idea to define and calculate an interaction index of interdependent (dependent from each other) projects is their model merger, i.e. hypothetical combination of the group of depended projects in the one vertical (no longer elementary) tube of the regional sandwich-model [1, 2]. Further arguments are based on similar principles to [5-15].

Let's describe and demonstrate a procedure of the model merger of interdependent projects on the easiest example. This example is implementation the pair of projects Π^{m_i} and Π^{m_j}, and implementation of the favorable for the natural monopoly project Π^{m_j} is dependent from implementation of the unattractive project Π^{m_i} (for example, due to some contractual agreements implementation of the favorable project Π^{m_j} is impossible without implementation of the unfavorable project Π^{m_i}). This situation is schematically shown in the fig. 2.5.

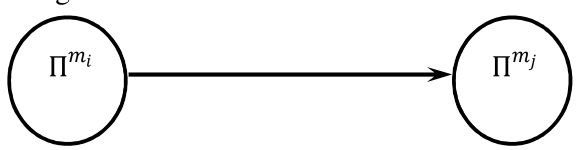

Fig. 2.5. The easiest scheme of the projects model merger

Let's unite all elementary tubes corresponding to the projects Π^{m_i} and Π^{m_j} to one a vertical tube of the sandwich-model, i.e. let's start consider all nodes (enterprises, organizations, managerial structures) involved in projects Π^{m_i} and Π^{m_j} implementation as a one vertical section$\Pi^{m_i} \cup \Pi^{m_j}$. The resulting (no longer elementary!) vertical section is denoted Π^{m_i}. Now the vertical section $\Pi^{m_i m_j}$ is considered as a one project of the regional program, which integral components are manufacturing tasks Π^{m_i} and Π^{m_j}.

It is obvious that one can calculate a new effectiveness ratio for a similar joint project $\Pi^{m_i m_j}$ using a general method of determination the isolated projects effectiveness ratios

The $k^{m_i m_j}$ is an interaction index of the joint projects Π^{m_i} and Π^{m_j}. Let's note that in fact, according to the developed calculation method, the coefficient $k^{m_i m_j}$ is calculated independently from the values of the effectiveness ratios k^{m_i} and k^{m_j} for each project separately because new initial data is used to determine the value $k^{m_i m_j}$ and the values k^{m_i} and k^{m_j} do not participate in the formula for defining $k^{m_i m_j}$. Indeed, total volumes of investments to both projects and incomes from loans and their time distribution become different, the natural monopoly benefit from projects aftereffects is distributed among two projects, probable company's income from placement investments on bank deposits changes and etc. Actually, all factors, taken into account when the effectiveness ratio is calculated and involved to its analytical mathematical expression, change.

Let's analyze in details what happens to the effectiveness ratio when a couple of interrelated projects Π^{m_i} and Π^{m_j} mergers to the joint project $\Pi^{m_i m_j}$. The general structure (schematic qualitative appearance of an analytic expression) of the effectiveness ratio k^m of the companies' interaction on an arbitrary project Π^m is

$$k^m = \frac{D^m}{D^m + Alt^m},$$

where D^m is an averaged income (predicted or already achieved in one or another form) from the Π^m project implementation. This value is formed by the incomes from the project Π^m aftereffects, income from investment activity, income from the project implementation and etc;

Alt^m is probable alternative company's income in the case of canceling the project Π^m implementation. This value is formed by incomes from banks deposits (as it would be in the case when the funds for the project Π^m implementation were allocated on bank deposits), volumes of the saved funds and resources in the case of complete refuse from the project Π^m implementation and etc. It is clear that $0 < k^m < 1$ and the Π^m project effectiveness ratio raises when the income D^m increasing and falls when the alternative income Alt^m decreases.

The value ψ^m inverse to the effectiveness ratio k^m (let's conventionally name it the extent of the project Π^m uselessness for the company) is:

$$\psi^m = \frac{1}{k^m} = \frac{D^m + Alt^m}{D^m} = 1 + \frac{Alt^m}{D^m}$$

It is obvious that the extent of the project uselessness is always greater than one $1 < \psi^m < +\infty$ and the extent of uselessness exceeds the one per the worsening summand $\frac{Alt^m}{D^m}$, which can interpreted as the ratio of the alternative income to the real income of the project Π^m implementation (i.e. the bigger this ratio is, the less attractive project Π^m is).

It is evident that when a pair of projects Π^{m_i} and Π^{m_j} mergers to the one joint project $\Pi^{m_i m_j}$ in the simplest case of the projects interdependence (i.e. there are no additional links between the projects increasing or decreasing projects profitability in the case of their joint implementation), there is merger of their real profitable parts: $D^{m_i m_j} = D^{m_i} + D^{m_j}$, and alternative profitable parts: $Alt^{m_i m_j} = Alt^{m_i} + Alt^{m_j}$. Hence, the effectiveness ratio of interaction in the joint project $\Pi^{m_i m_j}$ is the following (qualitative form):

$$k^{m_i m_j} = \frac{D^{m_i m_j}}{D^{m_i m_j} + Alt^{m_i m_j}} = \frac{D^{m_i} + D^{m_j}}{(D^{m_i} + D^{m_j}) + (Alt^{m_i} + Alt^{m_j})},$$

and the extent of the joint project uselessness (a value inverse to the effectiveness ratio) is:

$$\psi^{m_i m_j} = \frac{1}{k^{m_i m_j}} = \frac{(D^{m_i} + D^{m_j}) + (Alt^{m_i} + Alt^{m_j})}{D^{m_i} + D^{m_j}} = 1 + \frac{Alt^{m_i} + Alt^{m_j}}{D^{m_i} + D^{m_j}}.$$

It is evident that the worsening summand that increases the extent of the project $\Pi^{m_i m_j}$ uselessness is a value $\frac{Alt^{m_i}+Alt^{m_j}}{D^{m_i}+D^{m_j}}$, i.e. a ratio of the both projects total alternative income to the real income of the projects.

Let's consider a situation (which is very typical for real situation) when implementation the attaching of the influencing unattractive for the natural monopoly project and a low-income project Π^{m_i} is imposed to the natural monopoly instead of implementation the beneficial and highly-profitable project Π^{m_i}. In this case $k^{m_j} >> k^{m_i}$ and at the same time the effectiveness ratio is very close to zero $k^{m_i} \approx 0$ from the natural monopoly point of view. $k^{m_i} = \frac{D^{m_i}}{D^{m_i}+Alt^{m_i}} \approx 0$, therefore the real income of the unattractive project is close to zero $D^{m_i} \approx 0$ because in the case of any project implementation cancelling the alternative income is always non-negative $Alt^{m_i} > 0$.

To clarify the further conclusions one should imagine the limiting case $D^{m_i} = 0$ when the real income of unattractive imposed project Π^{m_i} is zero. In this limiting case the qualitative expressions to the effectiveness ratio $k^{m_i m_j}$ and the extent of uselessness of the joint project $\psi^{m_i m_j}$ is:

$$k^{m_i m_j} = \frac{D^{m_i m_j}}{D^{m_i m_j}+Alt^{m_i m_j}} = \frac{D^{m_j}}{D^{m_j}+(Alt^{m_i}+Alt^{m_j})},$$

$$\psi^{m_i m_j} = \frac{1}{k^{m_i m_j}} = \frac{D^{m_j} + (Alt^{m_i} + Alt^{m_j})}{D^{m_j}} = 1 + \frac{Alt^{m_i} + Alt^{m_j}}{D^{m_j}} =$$

$$= 1 + \frac{Alt^{m_j}}{D^{m_j}} + \frac{Alt^{m_i}}{D^{m_j}}.$$

Whereas $1 + \frac{Alt^{m_j}}{D^{m_j}} = \frac{1}{k^{m_j}} = \psi^{m_j}$ then:

$$\psi^{m_i m_j} = \frac{1}{k^{m_i m_j}} = 1 + \frac{Alt^{m_j}}{D^{m_j}} + \frac{Alt^{m_i}}{D^{m_j}} = \psi^{m_j} + \frac{Alt^{m_i}}{D^{m_j}},$$

It shows that the worsening summand (when unattractive project Π^{m_i} is joint to the effective project Π^{m_j}) is the value $\frac{Alt^{m_i}}{D^{m_j}}$, which presents ratio of the possible alternative income from the joint unattractive project Π^{m_i} to the real expected income from the highly-effective project Π^{m_j}.

There is an obvious and essential inequality from a practical point of view which ensures from the written expression for the extent of the joint project $\Pi^{m_i m_j}$ uselessness (in the case of ratio $k^{m_j} > k^{m_i}$ for the efficiencies of the joint projects):

$$k^{m_i} < k^{m_i m_j} < k^{m_j}$$

- the effectiveness ratio of the joint project $\Pi^{m_i m_j}$ is always lower than the efficiency of the most profitable project Π^{m_j} merger of the projects increases efficiency of the unattractive project Π^{m_i}.

3. Conclusion

It is obvious that the determined effectiveness ratio of the joint projects at the merger of projects solves the problem mentioned at the beginning of this article because its value takes into consideration influence of the projects to each other in the case of conditionality one project (profitable) by another (unattractive). Such method of the interaction index determination gives more weight to unattractive projects required to be implemented only for implementation of cost-effective point of the regional program. At the same time merger with unattractive project decreases effectiveness ratio of the profitable project, therefore one should understand that accepting a large number of unattractive points of regional program can significantly decrease an overall interaction index of its interaction in this region. Extent of possible reduction of the joint projects interaction index of the regional program (extent of possible concessions in negotiations) has to be determined by economic and in some cases political expediency.

There is one more important conclusion from the analysis of effectiveness ratio behavior at the merger of interrelated projects. When projects merge to the one joint regional program, the worsening summand, which decreases the integrated effectiveness ratio, are ratios $\frac{Alt^{m_i}}{D^{m_j}}$ of probable alternative income from the joining unattractive projects Π^{m_i} to the real income from highly-effective projects Π^{m_j}. Hence, there is a strategic direction of negotiations and the whole agreement process when regional programs are developed and approved: in order to increase effectiveness of the natural monopoly interaction in the region it is necessary to achieve the decrease of ratios $\frac{Alt^{m_i}}{D^{m_j}}$ for each unattractive project Π^{m_i} imposed to the natural monopoly.

Acknowledgements
Supported under the Agreement 02.A03.21.0006 of 27.08.2013 between the Ministry of Education and Science of the Russian Federation and Ural Federal University.
Supported under the President Russian Federation Grant MK-4227.2013.1

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Received: January 25, 2014